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इमारतों और संरचनाओं के लिए डिजाइन भार  
( भूकंप के अतिरिक्त ) — रीति संहिता  
भाग 4 हिम भार  
( तीसरा पुनरीक्षण )

Design Loads  
( Other than Earthquake )  
for Buildings and  
Structures — Code of Practice

Part 4 Snow Loads

( Third Revision )

ICS 91.100.10

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## FOREWORD

This Indian Standard (Part 4) (Third Revision) was adopted by the Bureau of Indian Standards after the draft finalized by the Structural Safety Sectional Committee had been approved by the Civil Engineering Division Council.

A building has to perform many functions satisfactorily. Amongst these functions are the utility of the building for the intended use and occupancy, structural safety, fire safety; and compliance with hygiene, sanitation, ventilation and day light standards. The design of the building is dependent upon the minimum requirements prescribed for each of the above functions. The minimum requirements pertaining to the structural safety of buildings are covered in the loading standards by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, wind loads, snow loads and other external loads, the structure would be required to bear. Strict conformity to loading standards, is necessary not only to ensure the structural safety of the buildings which are being designed and constructed in the country, thereby reducing the hazards to life and property caused by unsafe structures, but also to eliminate the wastage caused by assuming unnecessarily heavy loadings without proper assessment.

Not with standing what is stated regarding the structural safety of buildings, the application of the provisions should be carried out by competent and responsible structural designer who would satisfy himself that the structure designed taking into account the loads as per this standard, meets the desired performance requirements when the same is carried out according to relevant design standards.

This standard was first published in 1957 for the guidance of civil engineers, designers and architects associated with the planning and design of buildings. It included the provisions for the basic design loads (dead loads, imposed loads, wind loads and seismic loads) to be assumed in the design of buildings. In its first revision in 1964, the wind pressure provisions were modified on the basis of studies of wind phenomenon and its effects on structures undertaken by the special committee in consultation with the India Meteorological Department.

With the increased adoption of this standard, a number of comments were received on the provisions on live load values adopted for different occupancies. Keeping this in view and other developments in the field of wind engineering, the Sectional Committee decided to formulate this standard in the following five parts, during the second revision of IS 875 in 1987:

- Part 1 Dead loads
- Part 2 Imposed loads
- Part 3 Wind loads
- Part 4 Snow loads
- Part 5 Special loads and load combinations

This standard (Part 4) deals with snow loads on roofs of buildings. The Committee responsible for the preparation of this standard while reviewing the available snow-fall data at the time of second revision of the standards, felt the paucity of data on which to make specific recommendations on the ground snow load for different regions affected by snow-fall. In view that data on characteristic snow load on ground for different regions has now been made available by Defence Geoinformatics Research Establishment of Defence Research and Development Organization (erstwhile Snow and Avalanche Study Establishment), it has been decided to revise Part 4 of the standard dealing with snow loads on buildings and structures.

*(Continued to third cover)*

## *Indian Standard*

# DESIGN LOADS ( OTHER THAN EARTHQUAKE ) FOR BUILDINGS AND STRUCTURES — CODE OF PRACTICE

## PART 4 SNOW LOADS

*( Third Revision )*

### **1 SCOPE**

This standard (Part 4) deals with snow loads on roofs of buildings and structures. Roofs should be designed for the actual load due to snow or for the imposed loads specified in IS 875 (Part 2), whichever is more severe.

NOTE — Mountainous regions in northern and eastern parts of India are subjected to snow-fall. In northern India, parts of union territory of Jammu and Kashmir (J & K), union territory of Ladakh, Himachal Pradesh, Uttarakhand, and in eastern India, parts of Arunachal and Sikkim experience snow-fall of varying depths two to three times in a year.

### **2 REFERENCES**

The following standard contains provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	Title
875 (Part 2) : 1987	Code of practice for design loads (other than earthquake) for buildings and structures: Part 2 Imposed loads (second revision)

### **3 NOTATIONS**

- a)  $\mu$  (Dimensionless) — Nominal values of the shape coefficients, taking into account snow drifts, sliding snow, etc, with subscripts, if necessary.
- b)  $l_i$  (m) — Horizontal dimension with numerical subscripts, if necessary.
- c)  $h_i$  (m) — Vertical dimensions with numerical subscripts, if necessary.
- d)  $\beta_i$  (degree) — Roof and other surface slope.
- e)  $s_0$  (kPa) — Characteristic value of snow load on the ground with a specified annual exceedance probability.

f)  $s$  (kPa) — Snow load on roofs other surfaces.

g)  $A$  (m) — Site altitude above sea level.

### **4 SNOW LOAD ON ROOF(S)**

**4.1** The minimum design snow load on a roof area or any other area above ground which is subjected to snow accumulation is obtained by multiplying the characteristic value of snow load on the ground,  $s_0$  by the shape coefficient,  $\mu$  as applicable to the particular roof area considered and it is expressed as:

$$s = \mu s_0$$

where

$s$  = design snow load on plan area of roof, in kPa  
(1 kPa = 103 N/m<sup>2</sup>);

$\mu$  = shape coefficient (see 5); and

$s_0$  = characteristic ground snow load, in kPa.

#### **4.2 Characteristic Ground Snow Load ( $s_0$ )**

The characteristic ground snow load ( $s_0$ ) at any site is defined based on an annual probability of exceedance of 0.034 and corresponds to a mean return period of 30 years. The value of  $s_0$  (kpa) for any site in snow-bound regions of Indian Himalayas should be obtained using the procedure described in Annex A.

NOTE — Annex A gives the characteristic ground snow load map for union territory of Jammu and Kashmir, union territory of Ladakh, Himachal Pradesh, Uttarakhand and Sikkim resulting from studies conducted by Defence Geoinformatics Research Establishment (DRDO) Chandigarh.

#### **4.3 Partial Loading Due to Melting, Sliding, Snow Redistribution and Snow Removal**

A loading corresponding to severe imbalances resulting from snow removal, redistribution, sliding, melting, etc, (for example, zero snow load on specific parts of the roof) should always be considered. Such considerations are particularly important for structures which are sensitive to unbalance loading (for example, curved roofs, arches, domes, collar beam roofs, continuous beam systems). Water load due to ponding in flat roof as well as valley of pitched roof shall be taken as not less than 0.24 kPa.

#### 4.4 Ponding Instability

Roofs shall be designed to preclude ponding instability. For flat roofs (or with a small slope), roof deflections caused by snow loads shall be investigated when determining the likelihood of ponding instability from rain-on-snow or from snow meltwater.

### 5 SHAPE COEFFICIENTS

#### 5.1 General Principles

In perfectly calm weather, falling snow would cover roofs and the ground with a uniform blanket of snow and the design snow load could be considered as a uniformly distributed load. Truly uniform loading conditions, however, are rare and have usually only been observed in areas that are sheltered on all sides by high trees, buildings, etc. In such a case, the shape coefficient would be equal to unity.

In most regions, snow falls are accompanied or followed by winds. The winds will redistribute the

snow and on some roofs, especially multilevel roofs, the accumulated drift load may reach a multiple of the ground load. Roofs which are sheltered by other buildings, vegetation, etc, may collect more snow load than the ground level. The phenomenon is of the same nature as that illustrated for multilevel roofs in 5.2.4

So far sufficient data are not available to determine the shape coefficient in a statistical basis. Therefore, a nominal value is given in this standard. A representative sample of roof is shown in 5.2. However, in special cases such as strip loading, cleaning of the roof periodically by deliberate heating of the roof, etc, have to be treated separately. However, no reduction in load of snow on roof having underside insulation and/or internal heating system shall be done.

The distribution of snow in the direction parallel to the eaves is assumed to be uniform.

#### 5.2 Shape Coefficients for Selected Types of Roofs

##### 5.2.1 Monopitched and Simple Pitched Roofs

		Simple Flat and Monopitch Roofs	Simple Pitched Roofs (Positive Roof Slope)*
$0^\circ < \beta \leq 15^\circ$			$\mu_2 = \mu_1 = 0.80$
$15^\circ < \beta \leq 30^\circ$	$\mu_1 = 0.80$		$\mu_2 = 0.80 + 0.40\left(\frac{\beta - 15}{15}\right)$ $\mu_1 = 0.80$
$30^\circ < \beta \leq 60^\circ$	$\mu_1 = 0.80\left(\frac{60 - \beta}{30}\right)$		$\mu_2 = 1.20\left(\frac{60 - \beta}{30}\right)$ $\mu_1 = 0.80\left(\frac{60 - \beta}{30}\right)$
$\beta > 60^\circ$	$\mu_1 = 0$		$\mu_2 = \mu_1 = 0$

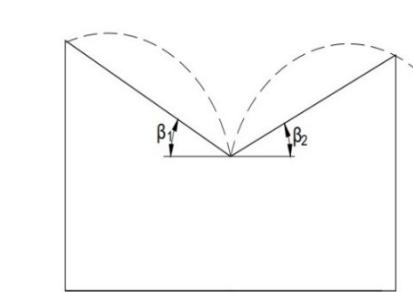
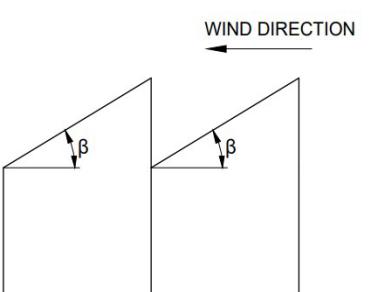
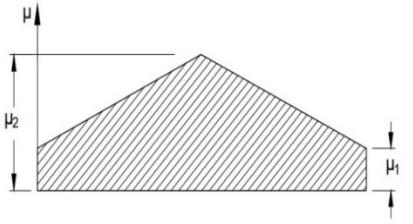
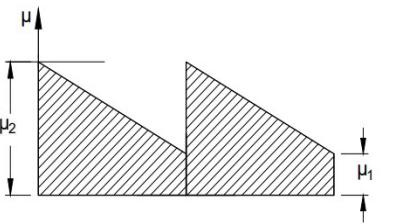
\*For asymmetrical simple pitched roofs, each side of the roof shall be treated as one half of corresponding symmetrical roofs.

#### NOTES

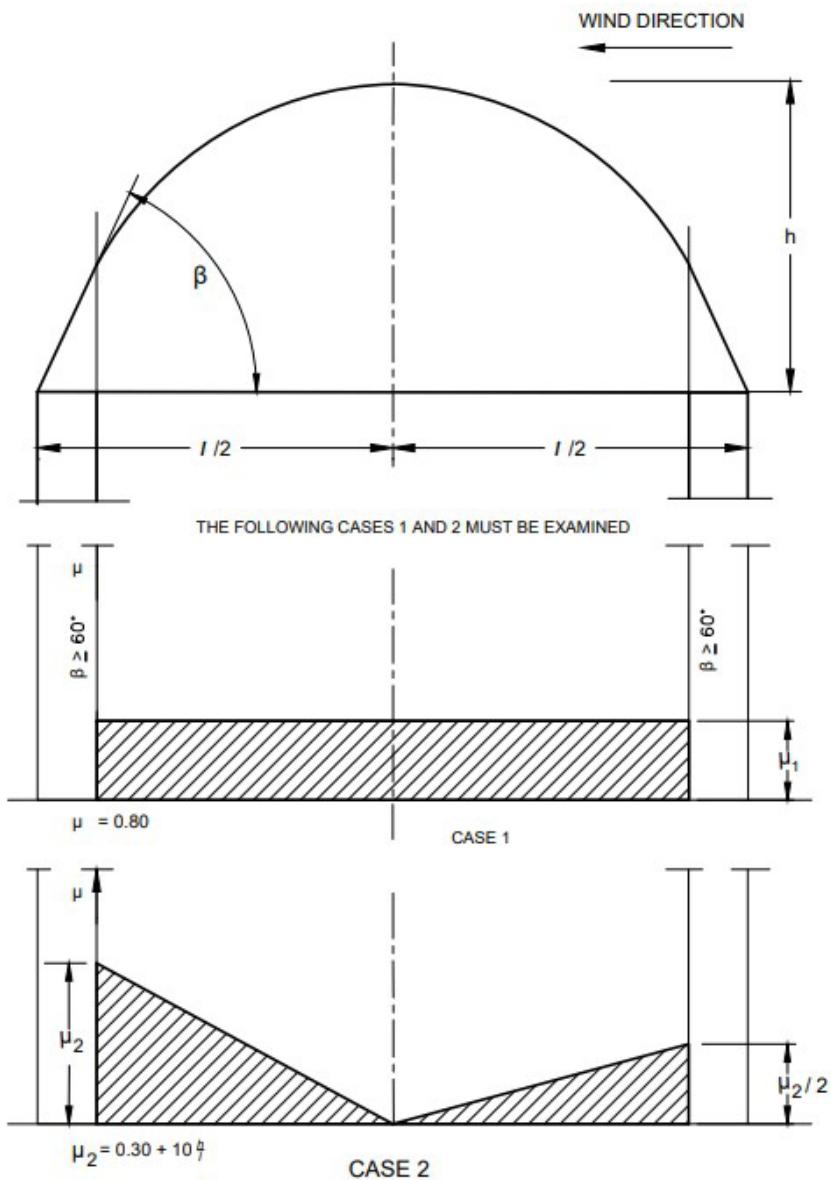
1 For monopitch roof, wind direction will not affect the value of  $\mu$ .

2 The values of  $\mu_1$  and  $\mu_2$  shall be reversed in case the wind direction changes from left to right for simple pitched roof.

### 5.2.2 Multiple Pitched Roofs

	    <p>Simple on Multiple Pitched Roofs (Negative Roof Slope)</p>	<p>Two – Span or Multispan Roofs</p>
$0^\circ < \beta \leq 30^\circ$	$\mu_2 = 0.80 \left( \frac{30 + \beta}{30} \right)$ $\mu_1 = 0.80$	$\mu_2 = 0.80 \left( \frac{30 + \beta}{30} \right)$ $\mu_1 = 0.80$
$30^\circ < \beta \leq 60^\circ$	$\mu_1 = 1.60$ $\mu_1 = 0.80 \left( \frac{60 - \beta}{30} \right)$	$\mu_2 = 1.60$ $\mu_1 = 0.80 \left( \frac{60 - \beta}{30} \right)$
$\beta > 60^\circ$	$\mu_1 = 1.60$ $\mu_1 = 0$	$\mu_2 = 1.60$ $\mu_1 = 0$

**5.2.3 Simple Curved Roofs**

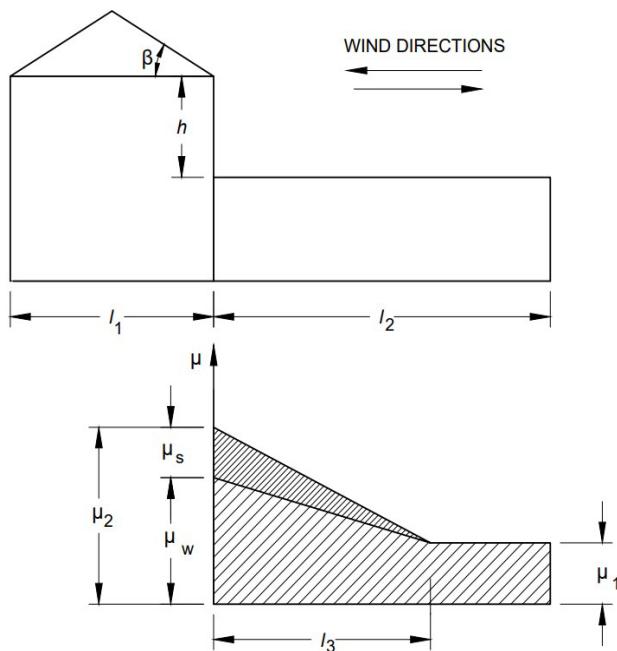


*Restrictions:*

$$\mu_2 \leq 2.3$$

$$\mu = 0 \text{ if } \beta \geq 60^\circ$$

### 5.2.4 Multilevel Roofs<sup>1)</sup>



$$\mu_1 = 0.80$$

$$\mu_2 = \mu_s + \mu_w$$

where

$\mu_s$  = due to sliding

$\mu_w$  = due to wind

$l_3 = 2h$  <sup>2)</sup> but is restricted as follows:

$$5 \text{ m} \leq l_3 \leq 15 \text{ m}$$

$$\mu_w = \frac{l_1 + l_2}{2h} \leq \frac{kh}{s_0} \text{ with the restriction } 0.80 \leq \mu_w \leq 4.0$$

where

$h$  is in meters

$s_0$  is in  $(\text{kN}/\text{m}^2)$

$$k = 2 \text{ kN}/\text{m}^2$$

#### NOTES

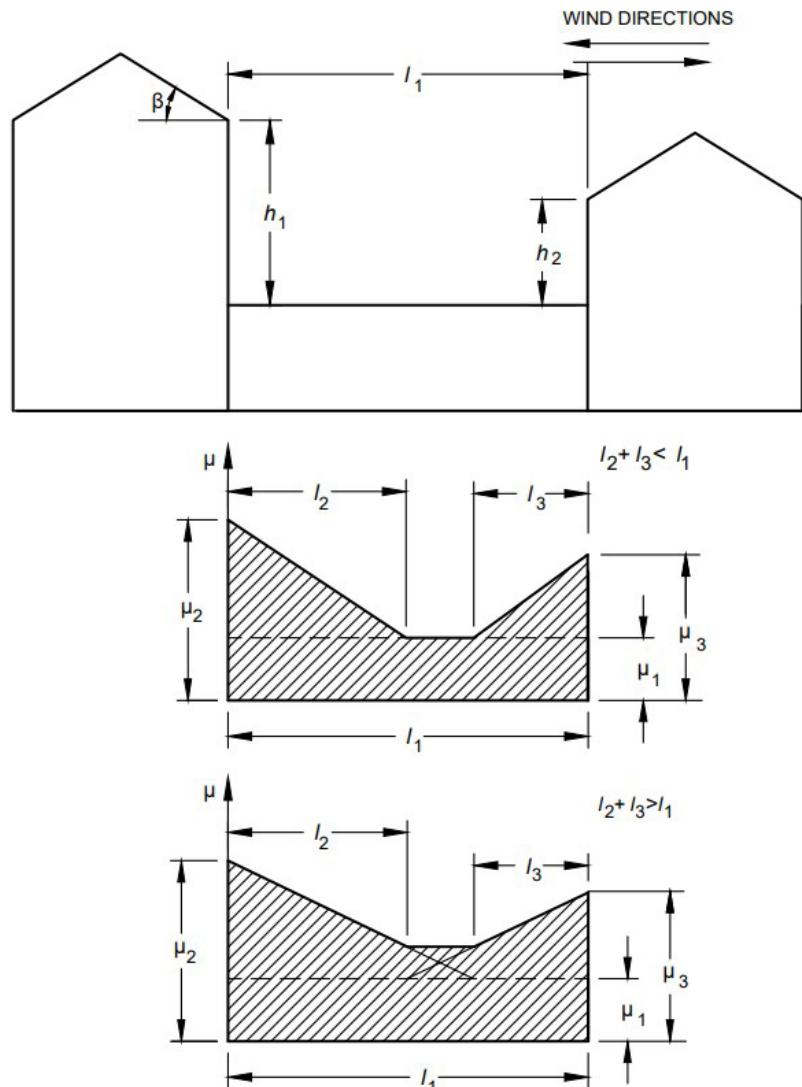
1 A more extensive formula for is described in Annex B.

2 If  $l_2 < l_3$ , the coefficient is determined by interpolation between  $\mu_1$  and  $\mu_2$ .

If  $\beta > 15^\circ$  :  $\mu_s$  is determined from an additional load amounting to 50 percent of the maximum total load on the adjacent slope of the upper roof and is distributed linearly as shown in the figure. The load on the upper roof is calculated according to 5.2.1 or 5.2.2.

If  $\beta > 15^\circ$  :  $\mu_s = 0$

**5.2.5 Complex Multilevel Roofs**



$$l_2 = 2h_1 ; l_3 = 2h_2 ; \mu_l = 0.80 ;$$

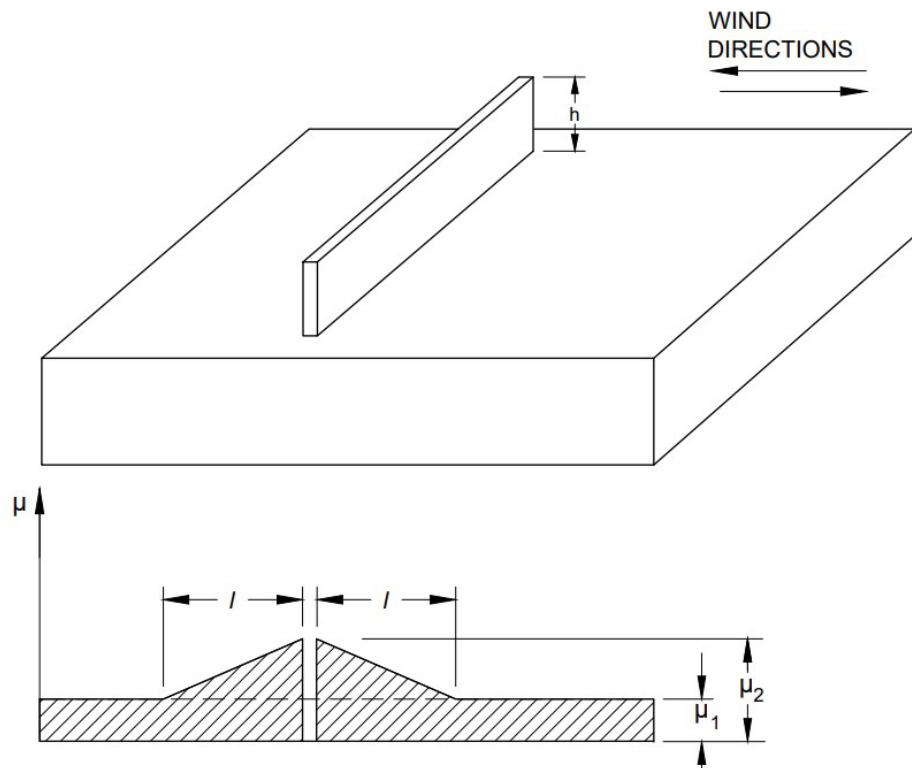
*Restrictions:*

$$5 \text{ m} \leq l_2 \leq 15 \text{ m}$$

$$5 \text{ m} \leq l_3 \leq 15 \text{ m}$$

$\mu_2$  and  $\mu_3 = \mu_s + \mu_w$ , are calculated according to **5.2.1, 5.2.2 and 5.2.4**

### 5.2.6 Roofs with Local Projections and Obstructions



$$\mu_2 = \frac{kh}{s_0}$$

$$l = 2h$$

Restriction:

$$0.80 \leq \mu_2 \leq 2.0$$

$$\mu_1 = 0.80$$

where

$h$  is in meters

$s_0$  is in )

$k = 2 \text{ kN/m}^2$

### 5.3 Shape Coefficients in Areas Exposed to Wind

The shape coefficients given in **5.2** and Annex B may be reduced by 15 percent provided the designer has demonstrated that the following conditions are fulfilled:

- a) The building is located in an exposed location, such as open level terrain with only scattered buildings, trees or other obstructions so that the roof is exposed to the winds on all sides and is not likely to become shielded in the future by obstructions higher than the roof within a distance from the building equal to ten times the height of the obstruction above the roof level; and
- b) The roof does not have any significant projections, such as parapet walls which may prevent snow from being blown off the roof.

NOTE — In some areas, winter climate may not be of such a nature as to produce a significant reduction of roof loads from the snow load on the ground. These areas are:

- a) Winter calm valleys in the mountains where sometimes layer after layer of snow accumulates on roofs without any appreciable removal of snow by wind; and

- b) Areas (that is, high temperature) where the maximum snow load may be the result of single snowstorm, occasionally without appreciable wind removal.

In such areas, the determination of the shape coefficients shall be based on local experience with due regard to the likelihood of wind drifting and sliding.

## 6 ICE LOAD ON WIRES

**6.1** Ice loads are required to be taken into account in the design of overhead electrical transmission and communication lines, over-head contact lines for electric traction, aerial masts and similar structures in zones subjected to ice formation. The thickness of ice deposit around may be taken to be between 3 and 10 mm depending upon the location of the structure. The mass density of ice may be assumed to be equal to  $900 \text{ kg/m}^3$ . While considering the wind force on wires and cables, the increase in diameter due to ice formation shall be taken into consideration.

## ANNEX A

*(Foreword and Clause 4.2)*

### CHARACTERISTIC GROUND SNOW LOAD

**A-1** This Annex presents the characteristic ground snow load computation procedure for the union territory of Jammu and Kashmir, union territory of Ladakh, Himachal Pradesh, Uttarakhand and Sikkim which is the result of scientific work carried out by Defence Geoinformatics Research Establishment (DGRE) under Defence Research and Development Organization (DRDO).

**A-2** The characteristic value of the ground snow load at any site is defined with a 3.4 percent annual exceedance probability or, equivalently, with a mean recurrence interval, MRI = 30 years. The site altitude is the altitude at which the structure is or will be located, measured from mean sea level. The procedure shall be used for the computation of characteristic ground snow load on sites with an altitude higher than 1 000 m and lower than 4 000 m from mean sea level.

**A-3** The characteristic ground snow load,  $s_0$  (kPa) to be used for any site in the union territory of Jammu and Kashmir, union territory of Ladakh, Himachal Pradesh, Uttarakhand should be obtained from the zone map shown in Fig. 1 and equation given below:

$$s_0 = 1.624 * [Z - 0.5] * \left[ 1 + \left( \frac{A}{2677} \right)^2 \right] \text{ kPa}$$

where

- $s_0$  = characteristic ground snow load (kPa);
- $Z$  = zone number (for example 1, 2, 3, 4 or 5) obtained from the zone map in Fig. 1; and
- $A$  = site altitude (m).

**A-4** The characteristic ground snow load  $s_0$  (kPa) to be used for any site in Sikkim should be directly obtained from the characteristic ground snow load map shown in Fig. 2.

**A-5** The ground snow loads for any mean recurrence interval of  $n$  years, different to that for the characteristic snow load,  $s_0$ , (which by definition is based on annual probability of exceedance of 0.034 that is MRI = 30 years) shall be calculated by the equation given below:

$$s_n = s_0 \left\{ \frac{1 - C_v \frac{\sqrt{6}}{\pi} [\ln(-\ln(1 - P_n)) + 0.57722]}{(1 + 2.1887C_v)} \right\}$$

where

- $s_0$  is the characteristic snow load on the ground with MRI = 30 years

$s_n$  is the characteristic snow load on the ground with MRI =  $n$  years

$P_n$  is the annual probability of exceedance (equivalent to  $1/n$ , where  $n$  is the corresponding recurrence interval in years)

$C_v$  is the coefficient of variation of annual maximum snow load.

**A-5.1** The coefficient of variation of maximum snow load at different snow-meteorological observatories of DGRE located in union territory of J & K, union territory of Ladakh, HP and UK ranges between 0.35 to 0.65. For application of above equation, a constant value of  $C_v = 0.5$  is recommended for all the zones to calculate snow loads on the ground for other probability of exceedance (for example, MRI of 50 years for structures where a higher risk of exceedance is deemed acceptable). The above equation is shown graphically in Fig. 3.

#### NOTES

**1** The characteristic ground snow load *versus* altitude relation as given above in equation and Fig. 1 is determined based on the snow depth observations at more than 70 field observatories of DGRE located in different parts of union territory of Jammu and Kashmir, union territory of Ladakh and states of Himachal Pradesh and Uttarakhand as well as High Asia Refined analysis (HAR10) dataset (HAR, Maussion et al., 2014).

**2** Since adequate snow depth measurements are not available for Sikkim region, hence the characteristic ground snow load map for Sikkim given in Fig. 2 is generated based solely on high asia refined analysis (HAR10) dataset (HAR, Maussion et al., 2014).

**3** Annex A does not apply for sites at altitudes above 4 000 m. For altitudes greater than 4 000 m specialist advice should be sought from DGRE on the characteristic ground snow loads likely to occur at the site.

**4** Unusual local effects have not been accounted for in the analysis undertaken to produce the characteristic ground snow load map given in Annex A. These include local shelter from the wind, which can result in increased local snow loads and local configurations in mountainous areas, which may funnel the snow and give increased local loading. Annex A is also not applicable for sites with permanent snow/ice cover throughout the year. If the designer suspects that there are unusual local conditions that need to be taken into account, Defence Geoinformatics Research (DRDO) may be consulted.

**5** In special cases where more refined data is needed, the characteristic value of snow load on the ground ( $s_0$ ) may be refined using an appropriate statistical analysis of long term records taken in a well sheltered area near the site.

**6** Ground characteristics snow load at any place depends on the critical combination of maximum depth of undisturbed aggregate cumulative snowfall and its density. In due course the characteristics snow load for states of Arunachal Pradesh will be included based on studies. Till such time the users of this standard are advised to consult DGRE for the specific information relating to the state of Arunachal Pradesh.

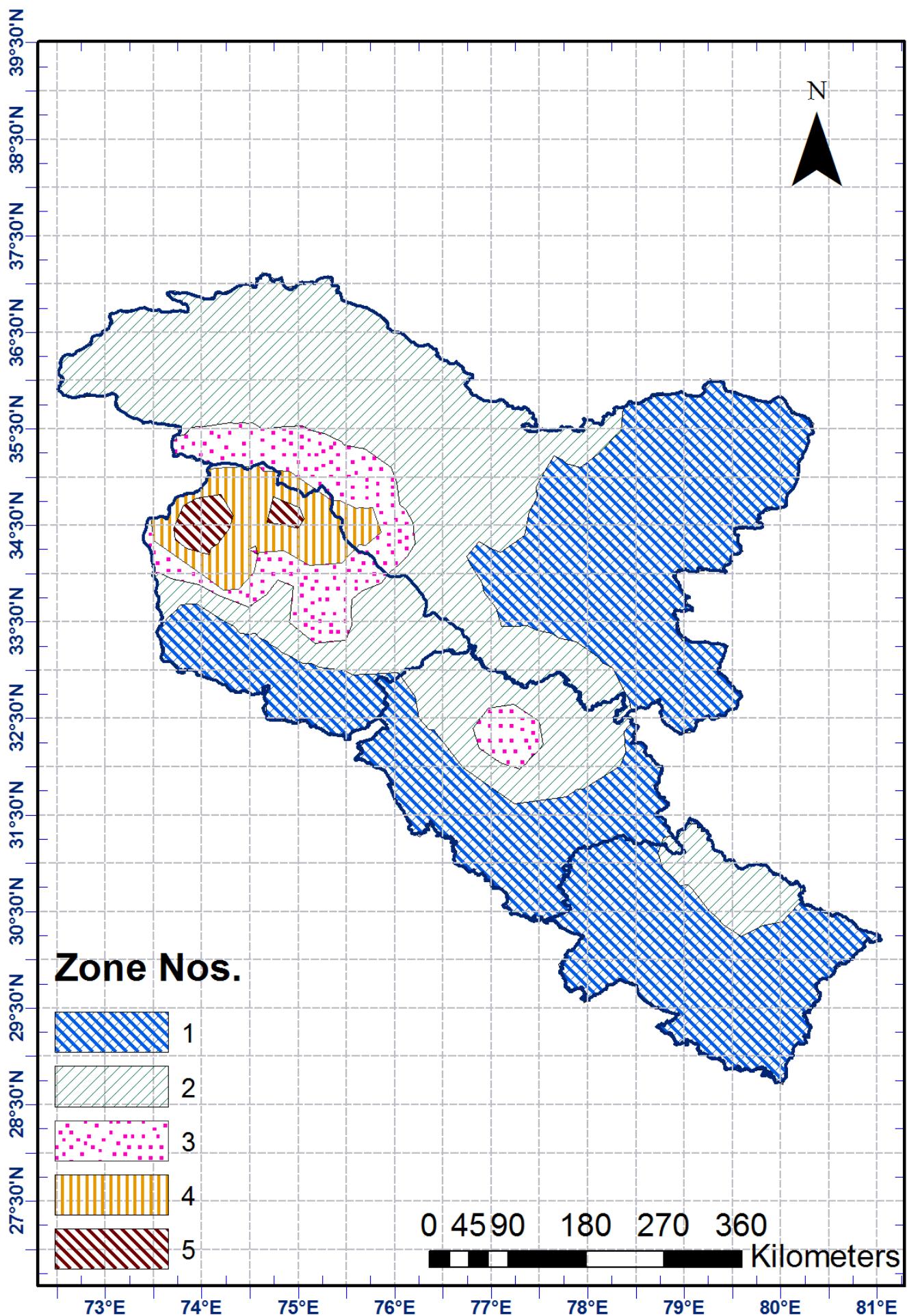


FIG. 1 ZONE MAP FOR J & K, LADAKH, HP AND UK AT 10 KM RESOLUTION

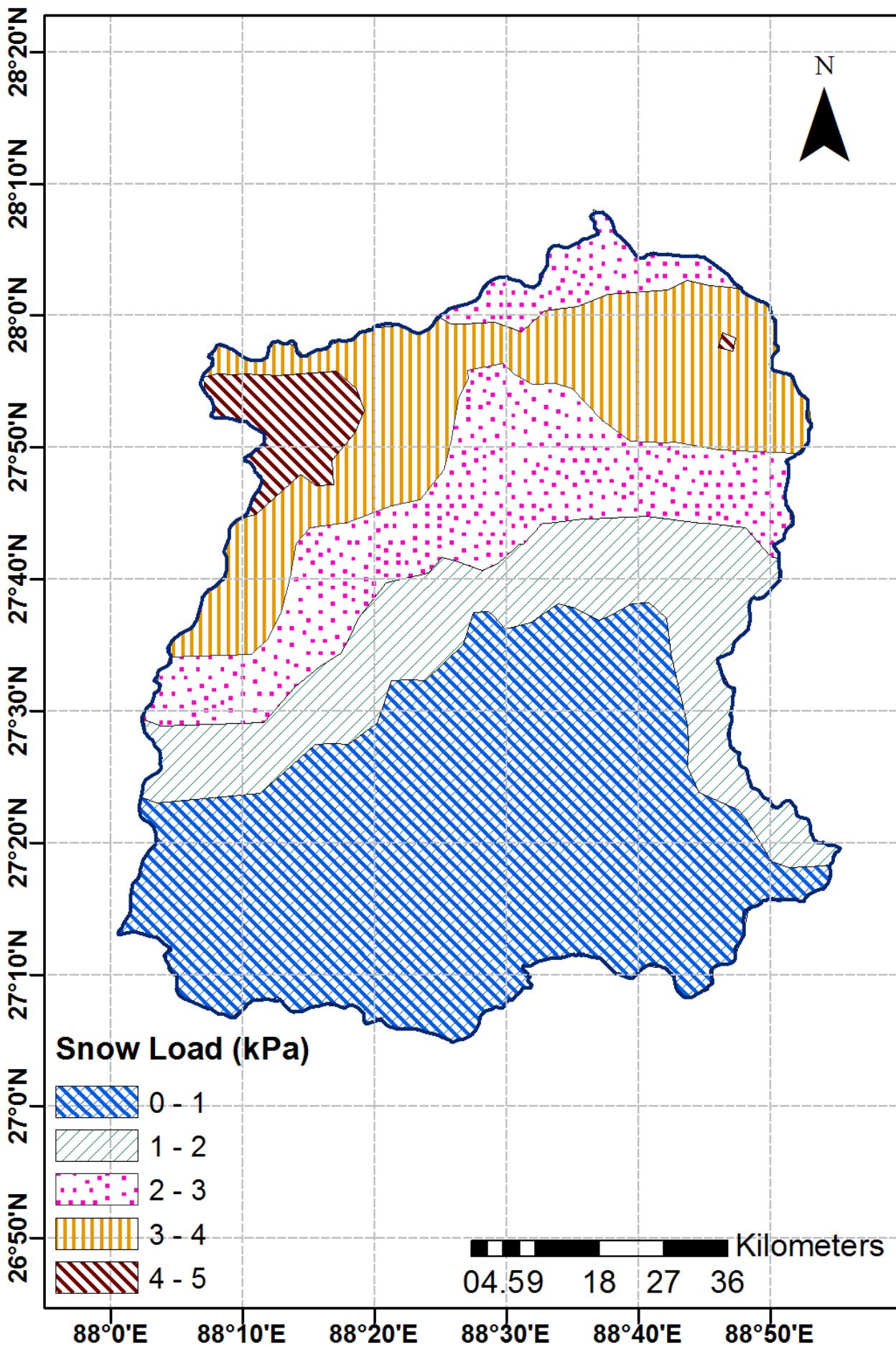


FIG. 2 CHARACTERISTIC GROUND SNOW LOAD MAP FOR SIKKIM AT 10 KM RESOLUTION

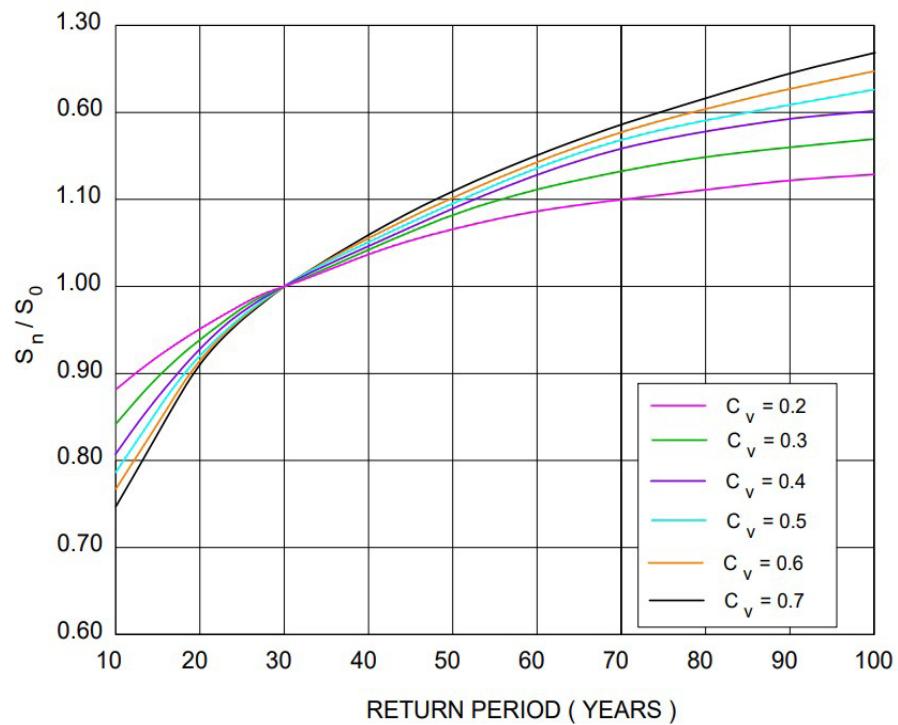
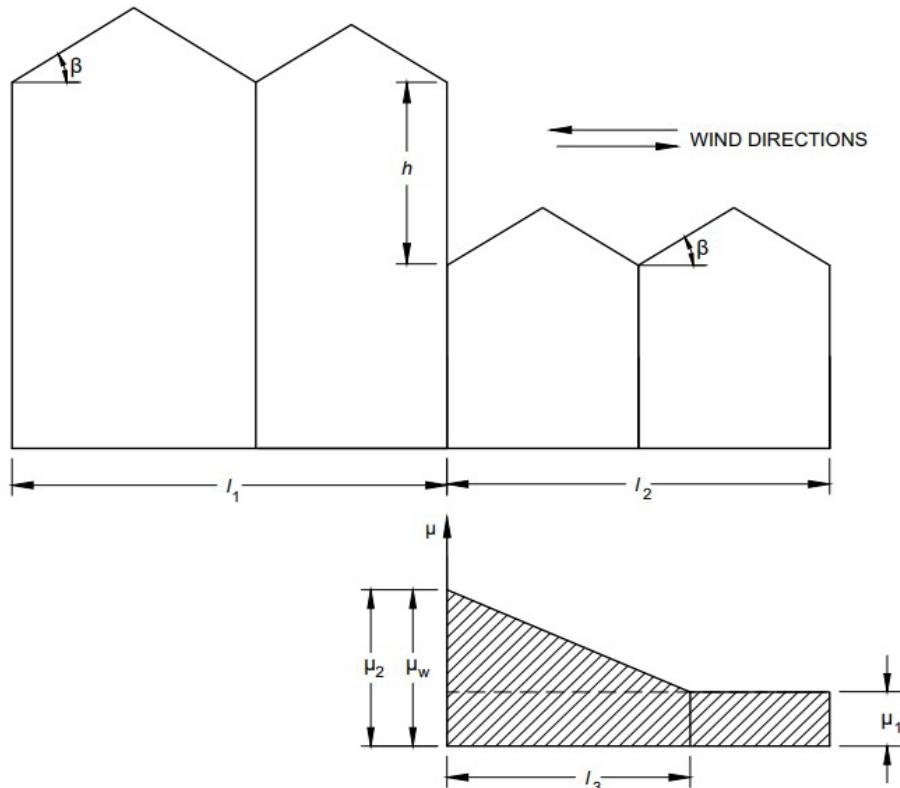


FIG. 3 ADJUSTMENT OF THE GROUND SNOW LOAD ACCORDING TO THE RETURN PERIOD

**ANNEX B**  
*( Clauses 5.2.4 and 5.3 )*  
**SHAPE COEFFICIENTS FOR MULTILEVEL ROOFS**

**B-1** A more comprehensive formula for the shape coefficient for multilevel roofs than that given in 5.2 is as follows:



$$\mu_w = 1 + \frac{1}{h} (m_1 l_1 + m_2 l_2)(l_2 - h)$$

$$\mu_1 = 0.8$$

$$l_3 = 2h$$

( $h$  and  $l$  in m)

Restriction:

$$\mu_w \leq \frac{kh}{s_0}$$

where

$s_0$  is in kPa ( $\text{kN/m}^2$ )

$$k = 2 \text{ kN/m}^2$$

$$l_3 \leq 15 \text{ m}$$

Values of  $m_1$  ( $m_2$ ) for the higher (lower) root depend on its profile and are taken as equal to:

0.5 for plane roofs with slopes  $\beta \leq 20^\circ$  and vaulted roofs with  $\frac{f}{l} \leq \frac{1}{8}$

0.3 for plane roofs with slopes  $\beta \leq 20^\circ$  and vaulted roofs with  $\frac{f}{l} > \frac{1}{8}$

The coefficient  $m_1$  and  $m_2$  may be adjusted to take into account conditions for transfer of snow on the roof surface (that is wind, temperature, etc).

NOTE — The other condition of loading shall also be tried.

## ANNEX C

*(Foreword)*

### COMMITTEE COMPOSITION

Structural Safety Sectional Committee, CED 37

<i>Organization</i>	<i>Representative(s)</i>
In Personal Capacity (80, SRP Colony, Peravallur, Chennai 600 082)	DR N. LAKSHMANAN ( <b>Chairman</b> )
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Larsen and Toubro Constructions Ltd, Chennai	DR R. SHIV SHANKER

<i>Organization</i>	<i>Representative(s)</i>
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Ministry of Road Transport and Highways, New Delhi	SHRI Y. BALAKRISHNA SHRI SANJEEV KUMAR ( <i>Alternate</i> )
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*(Continued from second cover)*

In this current revision of this standard, the following major modifications have been effected:

- a) A new term ‘characteristic ground snow load’ has been introduced and defined.
- b) Characteristic ground snow load maps for union territory of Jammu and Kashmir, union territory of Ladakh, and states of Himachal Pradesh, Uttarakhand and Sikkim have been introduced, resulting from studies conducted by Defence Geoinformatics Research Establishment (DRDO), Chandigarh.
- c) Equation for calculation of characteristic ground snow load has been suggested in Annex A.
- d) Clause relating to partial loading due to melting, sliding, snow redistribution, and snow removal has been included.
- e) Clause relating to ponding instability has been included.

In the preparation of this standard, the following overseas standards have also been examined:

ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures, American Society for Civil Engineers

ISO 4355 : 2013 Bases for design of structures — Determination of snow loads on roofs

The composition of the Committee responsible for the formulation of this standard is given at Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of specified value in this standard.

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This Indian Standard has been developed from Doc No.: CED 37 (16040).

### **Amendments Issued Since Publication**

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